



## Educational disadvantage and cigarette smoking during pregnancy

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### ABSTRACT

This study examined the influence of education on smoking status in a cohort ( $n = 316$ ) of pregnant women who were smokers at the time they learned of the current pregnancy. Subjects were participants in clinical trials examining the efficacy of monetary-based incentives for smoking-cessation and relapse prevention. In multivariate analyses, educational achievement was a robust predictor of smoking status upon entering prenatal care, of achieving abstinence antepartum among those still smoking at entry into prenatal care, and of smoking status at 6-month postpartum in the entire cohort and the subsample who received smoking-cessation treatment. In addition to educational attainment, other predictors of smoking status included smoking-related characteristics (e.g., number of cigarettes/day smoked pre-pregnancy), treatment, maternal age, and stress ratings. We suggest that strategies to increase educational attainment be included with more conventional tobacco-control policies in efforts to reduce smoking among girls and young women.

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### 1. Introduction

The 1964 publication of the U.S. Surgeon General's report documenting a causal relationship between cigarette smoking and cancer among other events precipitated a substantial decrease in the prevalence of cigarette smoking in the U.S. and other industrialized countries over the ensuing years (U.S. Department of Health, Education, and Welfare, 1964). Unfortunately, that decrease in smoking prevalence has not been evenly distributed. Young adults, disadvantaged individuals, and women have experienced substantially smaller declines in smoking prevalence (e.g., Graham et al., 2007). Indeed, during this period of decline in overall smoking prevalence, socioeconomically disadvantaged women, especially those who are educationally disadvantaged, have come to make up an increasing proportion of the shrinking population of current smokers (Graham, 2009; Graham et al., 2007; US Department of Health and Human Services, 2001).

The prevalence of smoking among women in the U.S. peaked in the mid 1960s at approximately 33% (U.S. Department of Health

and Human Services, 2007). As of 2006, the prevalence of smoking among U.S. adult women was 18% overall and 22% among women between the ages of 18 and 44 years (i.e., childbearing age) (U.S. Center for Disease Control and Prevention, 2008). Those rates vary substantially across different educational levels, with smoking prevalence being 10% among college graduates compared to 28% among women with less than 12 years of education.

These differences in smoking prevalence between women with different levels of educational attainment are striking and have substantive health implications. Especially germane to this report is that educational attainment is inversely related to the likelihood of being a smoker at conception. We report results from a study examining the relationship between educational disadvantage and smoking status at three critical points during pregnancy and early postpartum (i.e., start of prenatal care, end of the antepartum period, 6-month postpartum) among a cohort of 316 women who participated in clinical trials on the use of voucher-based incentives to promote smoking-cessation and prevent relapse among women who were smokers at the time they learned of their current pregnancy (Heil et al., 2008; Higgins et al., 2004b). First, we examined the relationship between educational disadvantage and the likelihood that a woman will quit smoking between learning of her pregnancy and beginning prenatal care. Smoking during pregnancy is the leading preventable cause of poor pregnancy outcomes (Cnattingius, 2004; Ershoff et al., 2004). Prior studies

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have demonstrated a strong positive association between years of education and the likelihood of quitting smoking in the interval from conception to initiation of prenatal care (Solomon and Quinn, 2004). Second, we examined the relationship between educational disadvantage and the likelihood of abstinence by the end of the pregnancy among women still smoking at first prenatal care visit. While quitting smoking as soon as possible after learning of a pregnancy is recommended, quitting smoking as late as the third trimester can produce substantial positive benefits for the fetus, including increases in growth (e.g., Bernstein et al., 2005). Third, we examined the relationship between educational disadvantage and the likelihood of abstinence from smoking at 6-month postpartum. Pregnancy is a major event in the life-course that provides opportunity for long-term changes in health-related behavior. This analysis examines how education relates to achieving longer term smoking abstinence in this cohort of women all of whom were smokers when they learned of this most recent pregnancy. To our knowledge, such a prospective examination of the relationships between educational disadvantage and smoking abstinence at critical points antepartum and postpartum in a single cohort of women has not been reported previously and offers new information on this overarching issue of educational disadvantage and smoking among women.

## 2. Methods

### 2.1. Participants

Participants ( $n = 316$ ) were recruited from one of four group-obstetric practices and a Women, Infants, and Children (WIC) program in the greater Burlington, VT area. Study eligibility was determined through a structured intake assessment. All study participants reported being smokers at the time of learning of their current pregnancy. Women with a biochemically verified self-report of no smoking for the 7 days prior to a study-intake assessment were eligible for relapse prevention studies ( $n = 110$ ). Those with a biochemically verified self-report of smoking within the 7 days prior to the intake assessment were eligible for smoking-cessation studies ( $n = 206$ ). Other inclusion and exclusion criteria were common across the relapse prevention and smoking-cessation studies and included  $\leq 26$  weeks pregnant, residing within the county within which the research clinic was located, planning to remain in the geographical area for 6 months following delivery, English speaking, not incarcerated, no prior participation in studies within this research clinic and not currently residing with someone who participated in a prior study. Women in the relapse prevention and cessation studies were randomly assigned to receive abstinence-contingent vouchers exchangeable for retail items or a control intervention in which vouchers were delivered independent of smoking status. Smoking abstinence was verified by urine-cotinine testing using enzyme immunoassay and a cutpoint of  $\leq 80$  ng/ml. All study participants provided written informed consent and study protocols were approved by the University of Vermont College of Medicine Institutional Review Board.

### 2.2. Procedures

Participants randomly assigned to abstinence-contingent voucher conditions earned the monetary-based incentives contingent on biochemically verified smoking abstinence, while those assigned to non-contingent voucher control conditions earned incentives of comparable monetary value independent of smoking status. All determinations regarding voucher delivery in the abstinence-contingent conditions were based exclusively on biochemical test results. The voucher-based incentive program operated throughout antepartum and 12 weeks postpartum. For further details about treatment conditions see Heil et al. (2008) and Higgins et al. (2004b). In addition to the intake assessment (before 26 weeks of pregnancy), study outcome assessments were completed with all study participants near the end-of-pregnancy (28–32 weeks), and 2-, 4-, 8-, 12-, and 24-week postpartum. Smoking abstinence at the intake and outcome assessments was defined as a biochemically verified self-report of no smoking in the past 7 days. Analyses described below are based on results from the study-intake, end-of-pregnancy, and 24-week postpartum assessments.

### 2.3. Statistical methods

Stepwise logistic regression analyses were used to predict smoking status at baseline, end-of-pregnancy, and 24-week postpartum using subject demographics, smoking characteristics, and psychiatric symptoms as potential explanatory variables. For these analyses, education was categorized as  $< 12$  years, 12 years, or  $> 12$  years, with  $< 12$  years functioning as the reference group. Significance to enter and

**Table 1**

Baseline characteristics of women recruited from obstetric practices who participated in the study ( $n = 316$ ).

Demographics	
Maternal age (years)	24.5 (5.3)
Caucasian (%)	95
Education (%)	
<12 years of education	26
12 years of education	43
>12 years of education	31
Weeks pregnant at baseline	9.8 (3.6)
Primigravida (%)	55
Married (%)	27
Private insurance (%)	30
Working for pay outside of home (%)	56
Smoking characteristics	
Age first started smoking cigarettes	15.0 (3.1)
Cigarettes per day pre-pregnancy	16.7 (9.8)
Living with another smoker (%)	71
Smoking allowed in home (%)	50
None or few friends/family who smoke (%)	30
Attempted to quit pre-pregnancy (%)	70
Number of quit attempts during pregnancy	1.0 (1.9)
Total score nicotine withdrawal questionnaire (0–4)	1.5 (0.9)
Psychiatric symptoms	
Stress rating (1–10)	5.2 (2.5)
Beck depression inventory	10.2 (6.9)
History of depressive symptoms (%)	32

Note: Values represent mean (SD) unless otherwise specified.

stay in the final regression model was based on  $p < 0.05$ . Because derived odds ratios correspond to a 1 unit change in each predictor variable, cigarettes per day were transformed to represent a 5-cigarette difference in order to represent a meaningful change in smoking. Analyses were performed using SAS software Version 9 (SAS Institute, Cary, NC).

## 3. Results

### 3.1. Study participants

Study participants were almost exclusively Caucasian, 69% completed 12 or fewer years of education, 73% were unmarried, and 70% were without private health insurance (Table 1). They smoked an average of 16.7 cigarettes/day prior to the pregnancy and began smoking on average at 15 years of age.

### 3.2. Abstinence at the intake assessment

This first analysis focused on whether education was a significant predictor of spontaneous quitting, that is, achieving abstinence prior to beginning prenatal care. In stepwise multiple regression, education was the second variable to enter the model (Table 2). Compared to women with less than 12 years of education, the odds of being abstinent prior to entering prenatal care were 5.5-fold greater among those with 12 years of education and 27.2-fold greater among those with more than 12 years of education.

The first variable to enter the model was the number of cigarettes/day women reported smoking prior to the pregnancy, with the odds of abstaining decreasing by 71% for every 5 additional cigarettes/day smoked pre-pregnancy (Hughes and Hatsukami, 1986). The four other significant predictors of abstinence in the order in which they entered the model were mean total score on the Minnesota Nicotine Withdrawal Questionnaire with increased scores being associated with decreased odds of abstinence, smoking permitted in the home being associated with decreased odds, having attempted to quit smoking prior to the pregnancy being associated with increased odds, and increased levels of stress experienced in the week prior to study entry being associated with decreased odds of abstinence.

**Table 2**

Stepwise logistic regression predicting abstinence entering prenatal care in full cohort. Significance to enter and stay based on  $p < 0.05$ .

Predictor variable	Odds ratios (95% C.I.)	p-Value
Cigarettes per day pre-pregnancy (per 5 cig increase)	0.29 (0.20–0.40)	<0.001
Education		<0.001
12 years vs. <12 years	5.5 (1.8–16.3)	
>12 years vs. <12 years	27.2 (8.0–92.8)	
MNWS total score (per 1 unit increase on 0–4 scale)	0.5 (0.3–0.8)	0.006
Smoking in home vs. no smoking in home	0.3 (0.2–0.7)	0.004
Attempted to quit pre-pregnancy vs. no quit attempts	2.7 (1.1–6.4)	0.02
Stress rating (per 1 unit increase on 10-point scale)	0.8 (0.7–0.9)	0.03

### 3.3. Predicting abstinence at end-of-pregnancy assessment

This analysis examined whether education predicted smoking status at the end-of-pregnancy assessment. Analyses were conducted with the cohort overall and also separately among those who were still smoking upon entering prenatal care and received cessation treatment and those already abstinent at the start of prenatal care who received relapse prevention treatment. In the analysis with the entire cohort, education again was the second variable to enter (Table 3). Compared to women with less than 12 years of education, the odds of being abstinent at the end-of-pregnancy assessment were 5.5-fold greater among those with 12 years of education and 9.2-fold greater among those with more than 12 years of education.

Among the five other variables to enter the logistic model, number of cigarettes smoked/day was again the first variable to enter, with the odds of abstinence decreased by 50% for every 5 additional cigarettes/day smoked pre-pregnancy. Other significant predictors of abstinence in the order in which they entered the model were treated with abstinence-contingent vouchers being associated with increased odds, number of quit attempts antepartum also being associated with increased odds, increases in baseline mean total score on the Minnesota Nicotine Withdrawal Questionnaire being associated with decreased odds, and having tried to quit smoking prior to the pregnancy being associated with increased odds of abstinence.

When the analysis was restricted to those who were still smoking upon entering prenatal care, education was the fifth variable to enter the model (Table 4). Compared to women with less than

**Table 3**

Stepwise logistic regression predicting abstinence at end-of-pregnancy assessment in full cohort. Significance to enter and stay based on  $p < 0.05$ .

Predictor variable	Odds ratios (95% C.I.)	p-Value
Cigarettes per day pre-pregnancy (per 5 cig increase)	0.5 (0.4–0.6)	<0.001
Education		<0.001
12 years vs. <12 years	5.5 (2.3–13.1)	
>12 years vs. <12 years	9.2 (3.7–23.1)	
Treatment condition (contingent vouchers vs. non-contingent vouchers)	4.9 (2.6–9.3)	<0.001
Number of quit attempts antepartum (per additional attempt)	1.3 (1.1–1.6)	0.02
MNWS total score (per 1 unit increase on 0–4 scale)	0.6 (0.4–0.9)	0.01
Attempted to quit pre-pregnancy vs. no quit attempts	2.3 (1.1–4.5)	0.02

**Table 4**

Stepwise logistic regression predicting abstinence at end-of-pregnancy assessment in those still smoking entering prenatal care. Significance to enter and stay based on  $p < 0.05$ .

Predictor variable	Odds ratios (95% C.I.)	p-Value
Treatment condition (contingent vouchers vs. non-contingent vouchers)	10.3 (3.7–28.4)	<0.001
Attempted to quit pre-pregnancy vs. no quit attempts	3.8 (1.3–10.9)	0.02
Number of quit attempts antepartum (per additional attempt)	1.3 (1.1–1.5)	0.03
Cigarettes per day pre-pregnancy (per 5 cig increase)	0.6 (0.5–0.9)	0.01
Education		0.02
12 years vs. <12 years	4.4 (1.5–12.8)	
>12 years vs. <12 years	2.8 (0.7–10.7)	

12 years of education, the odds of being abstinent at the end-of-pregnancy assessment were 4.4-fold greater among those with 12 years of education and 2.8-fold greater among those with more than 12 years of education.

Treatment was the first variable to enter the model, with the odds of achieving abstinence at the end-of-pregnancy being 10.3-fold greater with abstinence-contingent vouchers. Other significant predictors in the order in which they entered the model were greater number of attempts to quit smoking prior to the pregnancy and number of attempts to quit antepartum each associated with increased odds, and increases in the number of cigarettes/day smoked prior to the pregnancy being associated with decreased odds of abstinence.

In the analysis among those who had already quit smoking upon entering prenatal care, education was not a significant predictor. Only one significant predictor was identified and that was maternal age. The odds of remaining abstinent increased 1.3-fold (95% C.I.: 1.1–1.7,  $p = 0.008$ ) per additional year of age.

### 3.4. Predicting postpartum smoking status

In analyses on predictors of abstinence at 24-week postpartum, analyses were again conducted with the entire cohort as well as separately for those still smoking upon entering prenatal care and those who had already quit. In the analysis with the entire cohort, education was the second variable to enter the model (Table 5). Compared to women with less than 12 years of education, the odds of abstinence at the 24-week postpartum assessment increased 4.2-fold among those with 12 years of education and 5.7-fold greater among those with more than 12 years of education.

Consistent with the other analyses involving the entire cohort, number of cigarettes/day smoked pre-pregnancy was the first variable to enter the model, with the odds of abstaining decreasing by 50% for every 5 fewer cigarettes/day smoked pre-pregnancy. Other

**Table 5**

Stepwise logistic regression predicting abstinence at 24-week postpartum assessment in full cohort. Significance to enter and stay based on  $p < 0.05$ .

Predictor variable	Odds ratios (95% C.I.)	p-Value
Cigarettes per day pre-pregnancy (per 5 cig increase)	0.5 (0.4–0.7)	<0.001
Education		0.02
12 years vs. <12 years	4.2 (1.3–13.8)	
>12 years vs. <12 years	5.7 (1.7–19.1)	
Treatment condition (contingent vouchers vs. non-contingent vouchers)	2.3 (1.2–4.6)	0.02
Maternal age (per 1 year increase)	1.1 (1.0–1.2)	0.02

**Table 6**

Stepwise logistic regression predicting abstinence at 24-week postpartum assessment in those still smoking entering prenatal care. Significance to enter and stay based on  $p < 0.05$ .

Predictor variable	Odds ratios (95% C.I.)	p-Value
Treatment condition (contingent vouchers vs. non-contingent vouchers)	9.6 (2.0–45.4)	0.004
Education		0.02
12 years vs. <12 years	4.2 (0.8–21.7)	
>12 years vs. <12 years	11.9 (2.1–67.1)	

**Table 7**

Stepwise logistic regression predicting abstinence at 24-week postpartum assessment in those abstinent entering prenatal care. Significance to enter and stay based on  $p < 0.05$ .

Predictor variable	Odds ratios (95% C.I.)	p-Value
Maternal age (per 1 year increase)	1.1 (1.0–1.2)	0.004
Stress rating (per 1 unit increase on 10-point scale)	0.8 (0.7–0.9)	0.04

predictors in the order in which they entered the model were treatment with abstinence-contingent vouchers and older maternal age, each associated with increased odds of abstinence.

When the analysis was restricted to women still smoking upon entering prenatal care, education was the second variable to enter the model (Table 6). Compared to women with less than 12 years of education, the odds of being abstinent at the end-of-pregnancy assessment were 4.2-fold greater among women with 12 years of education and 11.9-fold greater among those with more than 12 years of education. The other predictor in this model was treatment, which entered first. Treatment with abstinence-contingent vouchers was associated with a 9.6-fold increase in the odds of being abstinent at 24-week postpartum.

In the analysis with spontaneous quitters who received relapse prevention treatment, education was not a significant predictor (Table 7). Two significant predictors were identified, with maternal age being the first variable to enter the model. The odds of being abstinent increased 1.1-fold for every additional year of age. The second variable to enter was stress ratings, with the odds of remaining abstinent decreasing by 1.2 for every one-point increase in the 10-point scale.

#### 4. Conclusions

The results of this study demonstrate that educational disadvantage is a robust predictor of smoking status during pregnancy and postpartum. The positive association between educational attainment and the likelihood of quitting smoking before entering prenatal care has been reported many times previously, but, to our knowledge, this is the first report to prospectively demonstrate a sustained association between education and smoking evident from the start of prenatal care through 6-month postpartum (Mullen, 2004; Solomon and Quinn, 2004).

The strength of the associations noted between education and smoking status in the present study also merits comment. With regard to being abstinent upon entering prenatal care, the odds were estimated to be 27-fold greater among those with more than 12 years of education compared to those with less than 12 years (Table 2). That is a striking difference. The 95% confidence intervals associated with that estimate were broad, but still the lower estimate in that confidence interval was 8-fold greater odds, which also represents a sizeable association. Robust increases in the odds of abstinence also were evident at the end-of-pregnancy assessment with 9-fold greater odds among those with >12 years of education compared to those with <12 years of education among the

entire cohort and approximately 3-fold greater odds within the subgroup who received smoking-cessation treatment (Tables 3 and 4, respectively). Lastly, robust associations between education and abstinence were observed at the 24-week postpartum assessment, with an estimated 6-fold greater odds of abstinence among those with >12 years of education compared to those with <12 years of education among the entire cohort and 12-fold greater odds within the subgroup who received smoking-cessation treatment (Tables 5 and 6, respectively). These robust associations between educational attainment and smoking status among pregnant and recently postpartum women are consistent with those reported previously based on a retrospective study in a stratified probability sample of U.S. households (Fingerhut et al., 1990; Kandel et al., 2009).

The associations observed between education and smoking status among the entire cohort at the end-of-pregnancy and 24-week postpartum assessments in the present study are not independent of the same relationship observed upon entering prenatal care. Indeed, these latter associations might best be considered as demonstrating that the earlier relationship is sustained through the antepartum and postpartum periods. Alternatively, the relationship between education and smoking status observed at the end-of-pregnancy and 24-week postpartum assessments among the subgroup who received smoking-cessation treatment is independent of the association observed upon entering prenatal care as these women were all smokers at that time. Instead, these associations provide strong evidence of an influence of education on the likelihood of eventually quitting smoking antepartum among women who had not yet done so at the start of prenatal care, and also an influence of education on the likelihood that these same women would sustain abstinence following delivery. These associations among the smoking-cessation women were evident after controlling for the influence of potential confounders including treatment, which itself increased the likelihood of abstinence at the end-of-treatment assessment by approximately 10-fold at both the end-of-pregnancy and 24-week postpartum assessment. Worth mentioning is that the treatment effects noted were attributable to voucher-based contingency management, which has features that accommodate the potentially short temporal horizons of educationally disadvantaged individuals by providing relatively immediate monetary-based incentives contingent on biochemically verified abstinence (Higgins et al., 2004a; Jones et al., 2009). The intervention has been demonstrated in several controlled trials to increase cessation rates among pregnant smokers (Donatelle et al., 2000; Heil et al., 2008; Higgins et al., 2008) and in the most recent trial to also increase fetal growth (Heil et al., 2008). The present results show that voucher-based contingency management does not eliminate the positive influence of educational attainment on cessation, but it does produce robust treatment effects even after controlling for the influence of education, which underscores the potential utility of this approach with educationally disadvantaged populations (Higgins et al., 2008).

While education was a robust predictor of smoking status antepartum and postpartum in the present study, the strongest predictor was the number of cigarettes smoked per day pre-pregnancy. Smoking frequency is a well-established predictor of the likelihood of achieving and sustaining abstinence among pregnant smokers and the present results provide still further support for that relationship (Fingerhut et al., 1990; Mullen, 2004; Solomon and Quinn, 2004). Other smoking-related variables, including rules prohibiting smoking in the home, nicotine withdrawal, and prior attempts to quit smoking also were predictors in the present study and prior studies as well (Mullen, 2004; Solomon and Quinn, 2004). In addition to these smoking-related variables, maternal age and self-reported stress levels were significant predictors in the present study, especially in analyses conducted with the women who were



abstinent at the start of prenatal care, which is consistent with knowledge about predictors in that population from prior studies (Solomon and Quinn, 2004). Another predictor of postpartum abstinence among those early quitters not examined in the present study but reported by our group previously is discounting of delayed monetary reinforcement (Yoon et al., 2007). In that study, women who were greater discounters of the value of delayed reinforcement in an assessment completed at approximately 3-month antepartum were significantly more likely to resume smoking by 6-month postpartum compared to women who discounted less. Discounting and educational attainment were significantly related in that study, but discounting remained a significant predictor of postpartum abstinence even after controlling for the influence of education. See the report by Jones and colleagues (this issue) for a discussion of relationships between temporal horizon and educational disadvantage.

Turning to practical implications of the poor outcomes observed among women with lower education in the present study, they certainly underscore the need for concern about the currently high U.S. high-school dropout rates. Only about 70% of children in U.S. public schools graduate high school, and graduation rates often fall below 60% for individual states (e.g., Georgia) and below 30% in some major cities (e.g., Detroit) (Swanson, 2008). The U.S. ranks towards the bottom among industrialized countries in high school graduation rates and, perhaps not surprisingly, among the top in teen-pregnancy rates (Organization for Economic Cooperation and Development, 2008; UNICEF, 2001). In addition to the problems of smoking during pregnancy focused upon in the present study, low education is associated with increased risk for a wide range of other serious acute and chronic health problems, including, for example, cardiovascular disease, pulmonary disease, diabetes, and asthma, as well as premature death (e.g., Cutler and Lleras-Muney, 2008; Grossman and Kaestner, 1997). We know of no formal experiments on educational attainment that allow definitive inferences regarding educational attainment and poor health outcomes. However, results from several of what can be considered natural experiments on the topic support a causal relationship (Currie and Moretti, 2003; Lleras-Muney, 2005), although others offer more equivocal results (e.g., Arendt, 2005). One such study is of particular relevance to the topic of the present report (Currie and Moretti, 2003). That study examined the effect of maternal education on infant health and maternal behavior at birth using U.S. Vital Statistics Natality files from 1970 to 1999. More specifically, the investigators examined relationships between infant health, maternal health-related behavior including cigarette smoking, and the expansion of 2- and 4-year colleges throughout the U.S. between 1940 and 1996. Ten-year trends in the measures of interest before and after the college openings were contrasted. The results revealed significant positive effects of education, with an additional year of maternal education being associated with a 30% reduction in the probability of smoking, a 10% reduction in the incidence of low birth weight, and a 6% reduction in the incidence of preterm birth, while also increasing the likelihood of marriage, entering prenatal care in the first trimester, among other changes. Effects largely appeared to be attributable to the opening of public 4-year colleges, which increased by approximately 20% the likelihood that women living in close geographical proximity to the new institutions would go on to obtain a 4-year degree rather than discontinue their education after receiving a high school diploma.

There are many paths by which increased educational attainment can potentially impact smoking vulnerability directly or indirectly. For example, greater education increases the likelihood of being married, having a spouse and friends who are non-smokers, being employed in a work setting with low smoking prevalence, being more knowledgeable about health risks, and having enhanced decision-making and problem-solving skills (Cutler and Lleras-Muney, 2008; Jones et al., 2009; Wetter et al., 2005a, b). Such a rich

array of potential paths to impact the target behavior would seem to make furthering academic attainment among girls and young women an attractive component in any comprehensive plan to reduce smoking risk and improve women's health. Certainly there is little risk of meaningful adverse health effects from increased educational attainment. Thus the only substantive drawback is fiscal, that is, that resources would be directed towards educational attainment when they might be better directed at another risk factor. Considering the strong positive associations between educational attainment and so many aspects of health, though, it seems difficult to imagine that any failure to impact smoking risk would not be offset by improvements in other important areas of health assuming of course some level of a causal relationship between educational attainment and health (Cutler and Lleras-Muney, 2008). That point notwithstanding, we are not advocating that resources be directed towards increasing educational attainment among at-risk girls instead of more conventional tobacco-control policies. Rather, we are advocating for a broader approach to policy that encompasses more distal risk factors in addition to the more proximal and conventional tobacco-control foci (see Clayton et al., 2009; Graham et al., 2007; Graham, 2009; Hemsing and Greaves, 2009; Kandel et al., 2009). Regarding the latter, the present results suggest that encouraging women of childbearing age to reduce their frequency of smoking if they are unable to quit, to make frequent quit attempts, and to adopt no smoking policies in their homes would be prudent steps towards helping them to quit smoking should they become pregnant.

The present study has notable limitations, including the use of a relatively small sample size, a cohort selected from a small metropolitan area with an almost exclusively Caucasian population, and a sample comprised exclusively of women willing to participate in treatment-outcomes studies. Generalizing results to girls and women from other regions, to other ethnic groups, and to community samples should be done cautiously. Those limitations notwithstanding, the results appear to be congruent with results that have been reported from studies conducted with larger and more diverse clinical and community samples demonstrating robust associations between educational disadvantage and smoking vulnerability among pregnant and recently postpartum women (Fingerhut et al., 1990; Kandel et al., 2009; Mullen, 2004; Solomon and Quinn, 2004).

Clearly, a great deal more research is needed to determine whether and to what extent educational attainment directly influences smoking vulnerability among girls and young women and the mechanisms involved in any causal relationships revealed. Such knowledge has the potential to have a tremendous impact on public health. Educational disadvantage is not only associated with smoking vulnerability among women of childbearing age, but also vulnerability to smoking in the general population, to other addictions, and to a wide range of acute and chronic health problems (Chilcoat, 2009; Cutler and Lleras-Muney, 2008). This relationship between educational disadvantage and health is a problem crying out for intense scientific scrutiny.

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## Contributors

All authors contributed to this report. The research reported is based on data collected in prior clinical trials conducted by Drs.

Higgins, Heil, Solomon, and Bernstein. Mr. Badger served as the statistical consultant in all of the trials and Ms. Skelly in more recent trials. Dr. Higgins was primary author of this report, Mr. Badger and Ms. Skelly conducted the statistical analyses, and Drs. Heil, Solomon, and Bernstein read and commented on early drafts of the report. All authors approved the final manuscript.

### Conflicts of interest

Dr. Higgins gave an invited lecture to personnel of GlaxoSmithKline.

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